Probing Chemical Reactions with High-Resolution X-ray Spectroscopy

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An atomic level understanding of how transition metal complexes separate charges and catalyze reactions is critically important for developing a new generation of efficient, environmentally friendly catalysts for many applications including water splitting, hydrogen production, CO_2 reduction and nitrogen fixation. By studying biological systems that employ earth abundant metals at their active sites and operate efficiently under ambient condition we can gain valuable insights that are beneficial to the design and understanding of function of manmade systems.

Synchrotron radiation (SR) based X-ray spectroscopy methods have been at the center of studying transition metal complexes for many years, specifically their electronic and local structure and ligand environment. New powerful synchrotrons with enhanced flux density and novel instrumentation are now enabling more complex studies. Recently this research has also been extended to X-ray free electrons lasers (XFELs), where ultrashort and ultra-bright X-ray pulses have opened the door to investigate ultrafast phenomena. Some of the XFEL methods are also making their way back to the synchrotron community. We will discuss some of the latest instrumentation and recent work where X-ray emission spectroscopy (XES) has been applied to various transition metal systems, at times simultaneously with scattering/diffraction techniques. We will outline some of the challenges and opportunities to further enhance these powerful research techniques.